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(54) TWIN HULL, SEMISUBMERSIBLE DRILLING VESSEL

(71) We, SANTA FE INTERNATIONAL CORPORATION, formerly known as Santa Fe Drilling Company, a Corporation organized and existing under the laws of the State of California, United States of America, of P.O. Box 2638, Santa Fe Springs, California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a semisubmersible floating vessel particularly for use with a drilling platform and other deck load having twin hulls and is adapted for deep water drilling and other operations.

In attempts to locate new oil fields, an increasing and significant quantity of well drilling has been conducted in offshore sea and like locations where a substantial body of water overlies the oil field. That has generated considerable interest and effort in offshore and deep water drilling. One current method of offshore drilling utitizes a fixed drill platform mounted on legs resting on or driven into the sea floor. These, however, are feasible for use only in relatively shallow depths of water normally not greater than about 300 feet, which is a realistic depth limit for practical commercial operations. Deep water drilling has heretofore been accomplished with the employment of specifically designed and constructed vessels or rigs which have certain inherent disadvantages and limitations noted hereinafter. A brief review of both offshore and deep water drilling methods heretofore practiced and the vessels or rigs employed therewith will provide a more clear appreciation and understanding of the present invention, as well as a clear distinction between these vessels or rigs employed in offshore drilling and those employed in deep water drilling.

An early method of offshore drilling, still currently employed, provides for the erection of a self-contained fixed platform which is supported by pilings driven into the sea floor and has a drilling rig, auxiliary equipment and crew's quarters located on the platform. At the conclusion of the drilling, a tender is brought to dismantle and remove the drilling equipment and, in the case of a dry hole, the entire self-contained platform is dismantled and removed by tender. A variation of the foregoing method provides a somewhat smaller platform similarly erected on piles and having a drilling rig located thereon while the auxiliaries, equipment and crew are located in a tender tied alongside. At the conclusion of the drilling, the platform is likewise either left for oil production or is dismantled and removed in the case of a dry hole. Another method employs a self-elevating barge which is towed to the drilling site and provided with columns or legs which are then lowered and embedded in the sea floor. The barge is then jacked up so as to clear the water surface and serves as a platform on which the drilling rig, crew, and auxiliary equipment are subsequently positioned for drilling operation. At the conclusion of the drilling, in the event of a producing well, a fixed platform generally is erected for continuing oil production and the self-elevating barge is towed to another drilling site. The foregoing methods are each feasible for use in relatively shallow water depths of normally 250 feet or less. The factors governing construction and operation of the vessels or rigs utilizing any of the foregoing arrangements are not significantly concerned with stability and other problems involved in conducting a drilling operation from a floating platform, as in deep water drilling, since the above-discussed rigs and vessels are constructed for sea bottom engagement.

Deep water drilling has heretofore been accomplished by means of surface floating

drilling vessels which are either towed or self-propelled to the drilling site and are self-contained in that the drilling rig, auxiliary equipment and crew's quarters form an integral part of the vessel. These floating drilling vessels are anchored over the drilling site and are normally provided with a central opening through which the drilling rig is operated. Drilling operations from these floating vessels are, however, highly restricted by sea state conditions, since excessive vessel motion in heave, pitch and roll can and does damage the drilling equipment as well as aggravate the problem of maintaining the vessel anchored directly over the drilling site. The stability characteristics of such a single-hulled drilling vessel are accordingly not conducive to efficient oil drilling operations. A catamaran type oil drilling vessel has been constructed; however, while that type vessel affords greater stability than a single-hulled vessel, it involves substantial problems which include excessive vessel motion due to wave action, overstability and resultant "snapping" action which tosses personnel about and may endanger the drill string and other equipment. The catamaran type vessel also suffers from the problem that it has no substantial "motion minimizing characteristics"—i.e. the characteristic of minimizing vessel motion due to excitation forces caused by wave action. Accordingly, while these vessels are not geographically limited to offshore drilling operations, they are limited to use in restricted or calm waters.

Deep water drilling operations have heretofore also employed semisubmersible platforms which, like the floating vessels, are completely self-contained. In this latter type, the platform is supported on a plurality of structural members joined at their lower ends to a base floatation structure which, when in unballasted condition, floats the entire structure on the surface of the water with the base structure having freeboard. After the vessel has been towed in freeboard condition to the drilling site, the base flotation structure is ballasted to submerge the same. To maintain the drilling platform above water in a relatively stabilized condition, the platform support structure includes a plurality of columns which extend between the platform and the base structure and are partially submerged to the extent that the displacement of such columns in conjunction with any residual displacement of the base structure supports the overall semisubmerged structure.

In one type of these prior semisubmersible platforms, the stabilizing patterns of the stabilizing columns form substantially symmetrical equilateral polygons with the columns located at the apices of the respective polygons which are normally square or triangular in shape. The equilateral symmetrical polygonal arrangement provides substantially identical righting moment about the roll and pitch axes, as well as any intermediate axes, regardless of wave direction. Another form of similar semisubmersible vessel includes a plurality of stabilizing columns interconnected adjacent their upper ends so that only the columns float in the water, with the columns again being arranged in a symmetrical equilateral polygon. In general, while such prior semisubmersible vessels provide adequate stability for well drilling operations, they have an inherent disadvantage of very low mobility between drilling sites due to the frontal area of the polygonally arranged columns and/or base structure presented to the water surface when such vessels are towed; their towing speed often does not exceed 2 knots. Additionally, to achieve the necessary displacement for supporting the full weight of drilling rig, deck load, etc., for such a vessel having a symmetrical equilateral polygonal configuration of base structure and stabilizing columns, such prior type vessels are of such large dimension that they cannot pass through narrow waterways like the Panama and Suez Canals, whereby their own use is accordingly restricted.

The present invention seeks to obviate, or at least reduce, the foregoing problems. Thus the present invention provides a semisubmersible vessel including; a pair of elongated hulls disposed in spaced side-by-side substantially parallel relation one to the other; a working platform and means connected to said hulls and said platform to support said platform in spaced relation above said hulls; said connecting means including a plurality of upstanding stabilizing columns located on said hulls on opposite sides of the pitch and roll axes, of the vessel respectively, said stabilizing columns extending above the hulls a predetermined effective height at least equal to the maximum anticipated wave height; said hulls having a combined displacement sufficient to float the vessel with the hulls having freeboard, and means for ballasting and deballasting the vessel to respectively submerge the hulls and a portion of said connecting means below the waterline and refloat the vessel with the hulls having freeboard, the displacement of the submerged hulls and the portions of said connecting means being sufficient to maintain the vessel buoyant in semisubmerged condition with the mean waterline located a distance above the hulls of substantially one-half the effective height of said stabilizing columns; said connecting means being spaced one from the other to provide an open frame area between the components thereof and between said hulls and said platform; said stabilizing columns being located to provide moment arms about said roll and pitch axes such that the buoyancy forces serve to estab-

lish righting moments proportional to the volumetric displacement of said submerged column portions; said stabilizing columns serving to provide motion minimizing characteristics in roll, pitch and heave when the vessel is in the semisubmerged condition.

Preferably said hulls have separate compartments spaced longitudinally therealong, said ballasting and deballasting means being operable to selectively ballast and deballast each of said compartments to stabilize the vessel about pitch and roll axes.

Thus a vessel according to the invention may include a drilling rig mounted on said platform over the space between said hulls.

It will however, be noted that a vessel according to the invention may also be used as a tender for other vessels, or as a platform for a heavy duty crane, dredge or other equipment.

In order that the invention may be better understood, several embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a side elevational view of the twin hull semisubmersible drilling platform and tender barge or vessel according to the present invention, with the vessel illustrated in the towing position;

Figure 2 is a side elevational view of the vessel similar to that of Figure 1 but illustrating the vessel in the floating semisubmerged drilling position;

Figure 3 is a plan view of the vessel, with portions broken out for ease of illustration;

Figure 4 is a horizontal sectional view taken about on line 4—4 of Figure 1;

Figure 5 is a transverse sectional view taken about on line 5—5 of Figure 4;

Figure 6 is a transverse sectional view taken about on line 6—6 of Figure 4;

Figure 7 is a bow end elevational view of the vessel in the submerged condition;

Figure 8 is an aft end elevational view of the vessel in the floating semisubmerged condition;

Figure 9 is a schematic view of one of the hulls of the vessel illustrating the ballast system therefor; and

Figures 10A and 10B are elevational and plan diagrammatic illustrations respectively of another embodiment of the vessel hereof.

Referring to the drawings, there is shown a combination semisubmersible drilling platform and tender barge (hereinafter referred to as a vessel) generally indicated at 10 comprising a pair of transversely spaced, elongated hulls 12 extending in spaced parallel relation and providing sufficient displacement to support vessel 10 in the floating condition with the hulls having freeboard indicated at f. Hulls 12 are substantially identical one with the other, each hull having a substantially rectangular cross section as seen in Figures 5 and 6 and arcuate bow and stern bottom portions 14 and 16 respectively as well as inwardly curved outboard side formations 18 at bow portions 14. Hulls 12 are thus substantially streamlined in shape to minimize resistance to towing through the water when vessel 10 is entirely supported by hulls 12 in the floating condition as illustrated in Figure 1.

A platform or main deck 20 is supported a predetermined height above hulls 12 by support structure comprising a plurality of longitudinally spaced, transversely extending truss formations generally indicated at 22 and a plurality of spaced stabilizing columns or bottles 24. The first, second, third and fifth truss formations 22, looking aft in Figure 4, each includes a lower transversely extending base tubular member 26 having opposite end portions overlying and secured to hulls 12 to maintain the latter in predetermined spaced relation preferably a distance at least equal to a hull beam. The lengths of the members 26 of the first, third and fifth truss formations 22 are identical while the base member 26 of the second truss formation is extended to the longitudinal centreline of the centrally located stabilizing columns or bottles 24. A plurality of diagonally and upwardly extending columns 28 are suitably secured at their lower ends to base members 26 and at their upper ends to platform 20 to form a pair of transversely extending V-shaped truss formations as best seen in Figures 5, and 8. The fourth truss formation 22 comprises a pair of V-shaped formations without a lower base member. The first, third and fourth truss formations 22 have outboard columns 30 joined at their lower ends to the outboard edges of hulls 12 and which extend upwardly and inwardly to the outboard edges of platform 20. A plurality of inboard columns 32 extend from the inner edges of hulls 12 upwardly to intermediate portions of platform 20 at longitudinally spaced positions along the hulls between transverse truss formations 22 to provide additional support for platform 20. It will be noted that the forwardmost truss formation 22 is spaced a considerable distance aft of the forward ends of hulls 12 to provide a substantial open area 33, unencumbered by support structure, between forward portions of the hulls. It will be apparent to one skilled in the art in light of the disclosure herein that the other specific support constructions and column and truss arrangements can be used in a vessel according to this invention.

As discussed more fully hereinafter, the support structure also includes stabilizing columns or bottles 24 extending upwardly from the upper surface of hulls 12 to platform 20 an effective height h (Figure 1) which is at least slightly greater than the

maximum anticipated wave height, the vertical distance between wave crest and trough. In the preferred embodiment, bottles 24 are located adjacent opposite ends of each hull 12 with a third bottle being provided on each hull intermediate the ends thereof. As seen in section in Figure 4, bottles 24 preferably are generally oval shaped with longitudinally elongated vertical sides and cylindrical fore and aft vertical end sections 34; besides providing streamlining in the direction of the vessel's longitudinal axis, this provides increased vessel stability. Use of columns 24 provides better motion minimizing characteristics when the vessel is in the floating semisubmerged condition. Stabilizing columns 24 are preferably constant in cross sectional area throughout their effective length. It will be understood that either or both the upper and lower ends of the columns may be reduced in cross section, for example, to form frusto conical sections, to provide mechanical connection between the columns and the hulls and platform which do not substantially affect the effective height or make the latter subject thereto.

A drilling platform 35 is spaced above main deck 20 adjacent the forward end of the vessel by a plurality of support beams 36 secured at their lower ends to platform 20. A deckhouse 38 is provided adjacent the forward end of drill platform 35 adjacent the forward edge thereof. Truss formations 40 have a pair of transversely spaced legs 42 secured at their lower ends to mounting members 44 fixed to platform 35 adjacent the aft edge thereof, legs 42 providing the aft support for trusses 40. There is supported on drill platform 35 a drill rig or derrick 46, having a pair of transversely spaced base truss formations 48 forming diverging legs which are pivotally secured at their lower ends to mounting members 44, whereby drill rig or derrick 46 can be pivotally moved between a vertically extending drill operating position seen in Figure 2, and a lowered inoperative position seen in Figure 1. The base portion 48 of derrick 46 seats against and is suitably secured by means not shown to truss formations 40 to maintain the same in a vertical position whereby a drill string 50 can be supported from the upper end 52 of derrick 46 so that string 50 extends between hulls 12 on the centerline of the vessel forward of the first truss formation 22 into open area 33. Main deck 20 has a deck superstructure 54 supporting a weather deck 56 mounting a pair of transversely spaced, upstanding beams 58 carrying a transverse beam 60 at the upper ends thereof for supporting the upper end of derrick 46 when the latter is pivoted to the lowered horizontal position shown in Figure 1. The main deck superstructure 54 houses the usual machinery, crew's quarters, and additional drilling equipment while weather deck 56 supports an after deckhouse 62 and a plurality of transversely extending pipe racks 64. A longitudinally extending catwalk 66 is positioned intermediate pipe racks 64 to provide access to any portion along the racks. The top deck of deckhouse 62 provides a heliport 70 and ballast control house 71.

In a preferred form hereof, particularly as seen in Figures 4, 7 and 8, columns or bottles 24 are disposed along the outboard sides of hulls 12 such that the inner faces of columns or bottles 24 lie parallel to and in vertical alignment with the centreline of the associated hull. The displacement and stability requirements of columns or bottles 24 are such that these columns or bottles have a transverse dimension locating an outboard portion 72 of each column 24 in overhanging relation to the outer hull sides, with the longitudinal axes of columns 24 being spaced laterally outwardly of the centerline of the hulls and located inwardly of and adjacent the outer hull sides. The centroids of the water plane areas defined by the cross sections of the columns or bottles 24 are thus located an extended distance from the centerline of the vessel on opposite sides thereof to develop larger moments of inertia of the water plane areas about the roll axis than would otherwise be the case if the longitudinal centerlines of each of the hulls and their associated stabilizing columns or bottles were coincident. The upper surfaces of the outer overhanging portions 72 of columns or bottles 24 form a continuation of main deck or platform 20 as seen in Figures 3 and 7 and each such upper surface adjacent the corners of the vessel mounts a pair of mooring pulleys 76. A pair of mooring winches 78 are located in a machinery space adjacent the bottom of each of the four corner stabilizing columns 24 and carry anchoring cables 80 which extend over pulleys 76 through chocks 84′. Winches 78, pulleys 76, and cables 80 serve to hold and maintain the vessel in fixed position over the drilling site when the vessel is floating in the semisubmerged condition.

A pair of cranes 84 and 86 are mounted on opposite sides of the vessel and may be of any conventional design, including the usual booms 88 and operating cabs 90. Cranes 84 and 86 may have any desired capacity, for example, 50 tons, crane 84 having an 80 foot boom and crane 86 having a 100 foot boom. The smaller crane 84 is preferably employed to service the self-contained drilling rig aboard vessel 10 such as for example raising or lowering the drill rig or loading and unloading pipes from pipe racks 64. The heavier crane 86 is preferably employed when vessel 10 is utilized as a tender, for example, in erecting or dismantling and generally servicing other drilling rigs. Crane 84 is pivotally mounted on a supporting column

member 92 fixed at its lower end adjacent the outboard side of one of the hulls while crane 86 is pivotally supported on a columnar member 94 spaced from intermediate column or bottle 24 and fixed at its lower end to the outboard side of the other hull 12.

As seen in Figure 9, hulls 12 are each divided into compartments 96 forming a plurality of ballast chambers for submerging and refloating the vessel. While only the starboard hull and ballast system therefor are illustrated in Figure 9, it will be understood that the port hull is similarly arranged and ballasted but is of the opposite hand. Ballast chambers 96 are selectively and independently ballasted and deballasted whereby the vessel may be submerged with the platform 20 remaining substantially level throughout the submergence thereof and the stability of the vessel in both roll and pitch may be corrected during submergence and retention of the vessel at drilling depth. To this end, a plurality of conduits 98 extend from a centrally located pump room P in each of the hulls in opposite longitudinal directions to the several ballast compartments 96, there being, in the preferred form, four ballast compartments in each of the aft and forward portions of each hull. A pair of conduits 100 extent aft from pump room P and terminate in a pair of compartments 102 which may be employed as supplemental ballast compartments or as compartments containing drilling water. While not a part of the ballasting system per se, a pair of bilge water conduits 104 extend fore and aft from pump room P into the bilges of the hulls and are in communication with the ballast pumps in a manner to be described.

The pump room is provided with a sea suction inlet indicated at 106 and an overboard discharge indicated at 108 controlled by suitable power operated gate valves 110 and 112, respectively, the hull sides being indicated by the dashed lines in Figure 9. A pair of pumps 114 and 116 are provided to suction sea water through inlet 106, past valve 110, through pumps 114 and 116 via conduits 118 and 120 respectively, past check valves 122 and 124, respectively, and into a conduit 126 communicating with a main ballast conduit 128. Opposite ends of main conduit 128 communicate with fore and aft ballast conduits 98 through suitable power operated valves 130, ballast conduits 98 being arranged in parallel at opposite ends of main conduit 128. With valves 110, 122, 124 and 130 open, the four ballast compartments at the fore and aft portions of each hull may be ballasted with sea water at an equal rate to maintain the platform substantially level when the vessel is being submerged to a drilling level or position.

To refloat the vessel with the hulls 12 having freeboard, valve 110 is closed and valves 112, 130 and 132 are opened. Pumps 114 and 116 operate to pump water in the same direction as before and accordingly suction main conduit 128 through conduit 134, thereby suctioning ballast conduits 98 and withdrawing ballast water therefrom for discharge through conduit 126, open valve 112 and outlet 108. It is thus readily seen that by selective operation of valves 110, 112, 130 and 132, selected compartments of compartments 96 may be ballasted and deballasted as desired to affect the attitude of the vessel about heel and trim axes, and to assist in the drilling operation. Moreover, this can be accomplished when the vessel is in any operating condition, i.e., floating with the hulls having freeboard, semisubmerged floating during drilling operations or any intermediate position during submerging or refloating operations.

The ballast drilling water conduits 100 are also connected in parallel to the aft end of main conduit 128 through suitable valve 138 similar to valves 130. Thus, the ballast drilling compartments 102 can be ballasted, deballasted, and selectively ballasted and deballasted similarly as compartments 96 by selected operation of valves 138 and the aforementioned valve 110, 112 and 132.

A fresh water intake or filling conduit 140, communicating with the machinery deck via uptake conduit 142, and a fresh water suction conduit 144, communicating with the ship's service fresh water pump 146, each communicate with a fresh water compartment 148 located aft of the pump room on the inboard side of the hull. A conduit 149 communicates between fresh water pump 146 and the machinery deck via uptake conduit 150. A pair of fuel oil suction conduits 152 communicate with fuel oil tank 154 located forward of the pump room on the inboard side of the hull and provides fuel oil to the machinery deck via an uptake conduit 156 by means of fuel pump 158. Drill water is pumped from the aft drilling water compartment 162 and the ballast drilling compartments 102 via conduits 164, 100 and 166, respectively, into a main drill water conduit 167 by a pump 168 which delivers the drill water via suitable valve 170 to the machinery deck via an uptake conduit 172. A drill water conduit 174 communicates with the forward drilling water compartment 176 and provides drill water to the machinery deck via pump 168 and conduit 172. Suitable valves 178 are provided in conduits 164 and 166 and these together with valve 176 in conduit 174 are selectively operable to fill and suction compartments 102, 162 and 176, whereby drill water may be transferred to and from the drilling rig and may be employed for the purposes of ballasting and deballasting the vessel.

It is a significant feature of the present

invention that vessel 10 can be towed between drilling sites at speeds on the order of 8 to 10 knots providing the present vessel with a mobility heretofore unavailable in prior semisubmersible type vessels. To this end, hulls 12 have a displacement when deballasted to support the entire weight of the vessel with the hulls 12 having freeboard. In this surface floating condition, it will be noted that the mast 46 is pivoted to extend horizontally as seen in Figure 1, thereby lowering the overall center of gravity of the vessel. Thus, when floating with the twin hulls having freeboard, vessel 10 has the greater righting stability and decreased roll angles characteristic of a catamaran type vessel. It will be seen that the support structure for platform 20 including truss formations 22 and stabilizing columns 24, is disposed above the water line and accordingly does not present a frontal area to the water to offer resistance to passage therethrough. In the floating condition, only twin hulls 12 displace water and the substantially streamline shape thereof as well as the absence of support structure in contact with the water permit the towing of the vessel at significantly higher speeds than heretofore possible with prior semisubmersible vessels.

When vessel 10 reaches the drilling site, the anchors (not shown) and anchor lines 80 are deployed to maintain the vessel directly over the drilling site. Hulls 12 are ballasted preferably by simultaneously ballasting fore and aft compartments 96 thereby maintaining the vessel level, to submerge the hulls below the water line with the vessel being submerged to the extent that bottles 24 are submerged for approximately half their effective height h, thereby locating the mean water line above the upper surfaces of the hulls at a distance of approximately half the distance between platform 20 and the upper surface of hulls 12. In this manner, the maximum anticipated wave is prevented from acting against hulls 12 and platform 20 and acts only in the open frame area between the hulls and the platform; this reduces the adverse effect of wave action on the vessel which has excellent motion minimizing characteristics in the floating semisubmerged condition. As the vessel is submerged, anchor lines 80 are made taut by operation of winches 78 to maintain the vessel over the drilling site when in the semisubmerged drilling position.

At the predetermined submerged depth, valves 130 are closed and the displacement of the submerged portions of columns 24 and the residual displacement of the hull is sufficient to maintain the vessel in the floating semisubmerged condition. It is a significant feature hereof that the foregoing vessel has optimal stability characteristics in the floating submerged condition. To this end, the columns are designed to provide a sufficiently large displacement of the submerged portions thereof that this, in combination with the submerged hull displacement, provides sufficient overall bouyancy to support the entire weight of the vessel including the drilling rig, crew's quarters, etc., in the floating semisubmerged condition as well as a sufficiently large water plane area at the aforementioned depths of submergence to provide an adequate righting moment to return the vessel to a level position. The columns are also designed to provide a sufficiently small displacement of the submerged portions thereof to preclude large amplitudes of vessel displacement in heave and a sufficiently small water plane area to provide a longer period of and hence a gentle roll. The columns provide a roll sufficiently slow as to preclude tossing about of operating personnel on platform 20 (which as seen in Figure 2 is located a considerable height above the roll axis RA, Figure 4, when the vessel is semisubmerged) and a roll rate sufficiently fast to provide adequate stability about the roll axis. The vessel attitude about heel and trim axes can be corrected by selected ballasting of compartments 96, and, if necessary, compartments 102. The stability and motion minimizing characteristics thus afforded the vessel are optimum for a vessel of the foregoing construction.

To refloat the vessel, the anchor lines are loosened or the anchors are shipped aboard the vessel and ballast compartments 96 and/or compartments 102 are pumped to evacuate the water therein as hereinbefore described. The combined hulls displacement and the submerged column displacement are sufficient to raise the vessel to the surface floating condition illustrated in Figure 1, the stabilizing columns acting continuously to stabilize the vessel during refloating operations.

In the surface floating condition, the stability characteristics of the twin hull vessel afford use thereof as a tender with one or both of cranes 84 and 86 being operable to service another drilling rig or vessel. The vessel is self-contained in that crew's quarters, the required auxiliary equipment, and deck load, etc. are on board and accordingly the vessel can provide these facilities to service another drilling structure. Auxiliary equipment, crew's quarters, etc. may be located within bottles 24 in addition to being located on platform 20.

Certain basic principles are employed in the construction of the present vessel:

(1) A pair of elongated, laterally spaced hulls 12, preferably of streamlined form, and in substantially paralell relation, are employed to provide greater towing speeds as well as high stability.

(2) The hulls have sufficient displace-

ment to float the vessel with the hulls having freeboard, and the hulls are compartmented for ballasting in a predetermined volumetric relation to the stabilizing bottles 24 as noted in points (5) and (6) hereafter.

(3a) The vessel should have at least six stabilizing columns or bottles 24, with half of the columns being disposed on each hull on opposite sides of the roll axis RA and a first and second pair of such columns on opposite sides of the pitch axis PA, Figure 4, (passing through the center of flotation), with the third middle pair of such columns located adjacent or intersected by the pitch axis when a total of six stabilizing columns are used.

(3b) More specifically, if an odd number of pairs of stabilizing columns are employed, the middle pair should be adjacent the pitch axis PA and the other pairs of columns should be disposed in equal numbers on opposite sides of the pitch axis PA and in a generally symmetrical relation, as illustrated, for example, in Figure 4; whereas when an even number of pairs of stabilizing columns are employed, the same number of pairs are located on the opposite sides of the pitch axis PA in a generally symmetrical relation thereto, as illustrated for example in Figures 10A and 10B.

(4) To stabilize the vessel, each of bottles 24 should have a predetermined area which is constant in cross section throughout the effective height thereof per point (6) below.

(5) The stabilizing bottles 24 are constructed so that their lower halves provide a combined displacement together with any residual displacement of ballasted hulls 12 so as to float the vessel in a semisubmerged condition meeting the requisites of point (6).

(6) The effective height of the stabilizing bottles 24, which is defined by the distance h between the upper surfaces of hulls 12 and the underside of the working platform 20, may be equal to and preferably slightly greater than the maximum anticipated wave height from crest to trough, such height being substantially unaffected by any slight changes in configuration for the mechanical connection between the bottles and either of the hulls and platform.

(7) When semisubmerged, the stabilizing bottles provide stabilizing righting moments about the roll axis RA and the pitch axis PA in proportion to their volumetric displacement and their respective distances from each such axes, whereby such righting stabilizing moments are of a magnitude to maintain the vessel within optimum limits of rolling inclination and period of roll for drilling operations.

An illustrative preferred embodiment of a vessel constructed according to the present invention has an overall length of 270 feet at hulls 12 with each hull 12 having a beam of 30 feet and inside spacing of 30 feet from each other, providing an overall hull beam of 90 feet. The effective height h of the stabilizing bottles 24 is 24 feet. The centroids of the bottles 24 are equally spaced 41½ feet from the vessel's longitudinal centerline. The pairs of outer stabilizing columns 24 are spaced about 212 feet apart, with the central pair of columns 24 being midway between. The length and width of the bottles 24 are 34 feet and 32 feet respectively with the ends being formed cylindrical in shape providing an overall area of approximately 415 square feet. To provide larger righting moment about the roll axis RA, the bottles 24 preferably overhang 8 feet beyond the outboard hull sides providing an overall vessel beam of 106 feet, and accordingly an overall length-to-width ratio of approximately 2½ : 1.

Summary of Construction and Operation

Thus, the present invention provides a twin hull, semisubmersible combination drilling platform and tender barge having a plurality of connecting members including spaced upstanding stabilizing columns or bottles 24 which are fixed at their lower ends to a pair of laterally spaced, elongated parallel hulls 12 and which support a drilling platform 20 including crew's quarters and machinery spaces, at their upper ends. The spaced hulls are compartmented to provide ballast tanks 96 which are deballasted when the semisubmersible is towed to and from drilling sites to provide sufficient hull displacement to support the semisubmersible vessel (and its drilling rig, crew's quarters and machinery spaces) with the hulls having freeboard. The hull compartments 96 provide a safety factor in the event of a collision or otherwise rupturing certain of the compartments. At the drilling site, the hulls' ballast tanks 96 and tanks 102, if necessary, are ballasted to submerge the hulls normally to a distance about one-half the effective height of stabilizing columns 24 which is about one-half the height of the maximum anticipated wave whereby platform 20 remains supported above the maximum anticipated wave height. The displacement required to support the platform/barge in the semisubmerged floating condition is provided by the hulls and portions of the stabilizing columns 24, the vessel in this condition being otherwise unsupported. The present semisubmersible vessel is thus different from the previously discussed prior types of self-contained fixed platforms, self-elevating barges and surface floating vessels as the present vessel operates in two distinct conditions;

(1) floating with the hulls having freeboard and (2) floating semisubmerged; this, the vessel involves stability and structural criteria differing from the abovementioned prior type vessels or fixed platforms. The semisubmersible vessel of this invention is further distinguished from prior type vessels in that sole support in both conditions is provided by buoyancy whereby factors for ground-supported operation are not involved.

Mobility between and stability at the drilling sites are prime requisites for an effective semisubmersible vessel. The vessel of this invention can be towed between drilling sites at speeds greatly in excess of towing speeds of prior semisubmersibles, due to use of twin hulls 12 having sufficient displacement to locate the stabilizing bottles 24 above the waterline when the vessel is in the floating condition. Contrary to the provision of interconnecting base structure at the lower ends of polygonally located stabilizing columns as in prior semisubmersibles, whereby that base structure creates significant drag when those submersibles are towed on the water surface so that towing speeds are limited to about two knots, the streamlined parallel twin hulls 12 of the present semisubmersible vessel are interconnected only above the waterline when the vessel is in the freeboard floating condition thus enabling significantly greater towing speeds of about 8 to 10 knots, thereby greatly reducing the time in transit between drilling sites. Moreover, by utilizing twin streamlined parallel hulls 12, the overall beam of the present semisubmersible vessel is significantly less than the width of prior equilateral symmetrical polygonally shaped semisubmersible vessels, while the present vessel can support a corresponding weight in drilling platform, machinery and equipment. Further, this construction enables the present semisubmersible vessel to be towed through narrow waterways such as the Suez and Panama Canals, while previous polygonally shaped semisubmersibles could not. Additionally, the twin hulls feature of the present semisubmersible vessel provides high stability in the freeboard floating condition notwithstanding the relatively high locus of the center of gravity of the overall vessel necessitated by spacing the drilling platform, machinery and equipment at an effective height above the hulls based on the anticipated sea states in which the vessel will operate, as hereinafter more fully discussed.

The ability of the present semisubmersible vessel to provide a stable floating platform in various wave conditions without recourse to the symmetrical equilateral polygonally shaped structures of prior semisubmersibles heretofore thought necessary to stabilize the same in the floating semisubmerged condition, is high significant as it permits use of the above-described twin hull support, thus combining in a single vessel the desirable stability characteristics of a twin hulled vessel having freeboard and a semisubmersible vessel and drilling platform having stabilizing columns 24. To stabilize the present vessel and its drilling platform 20 in the floating semisubmerged condition, wave action against the vessel must be minimized as a cause of unfavorable motion characteristics. By submerging the twin hulls to half the effective height of bottles 24, wave action against the larger surface area of hulls 12 or the drilling platform is substantially eliminated, and waves act only against the relatively small area of open support structure and framework between the drilling platform and the hulls. The location, size and configuration of the vessel's stabilizing columns or bottles 24 are effective: to maintain the vessel in a buoyant condition; to locate and maintain the drilling platform 20 and hulls 12 respectfully above and below the maximum wave amplitude; to preclude large vessel motions in heave due to large bottle displacement and the inertial properties of the vessel; to provide a sufficient righting moment when unstabilized about roll and pitch axes of a magnitude to correct the rolling and pitching motion; to minimize the period of rolling and pitching motion; and to generally minimize the effect of the wave action against the vessel when in the floating semisubmerged condition.

The stabilizing columns 24 are located adjacent opposite end portions of each hull with an additional column located on or adjacent the transverse axis through the center of flotation to provide moment arms about roll and pitch axes such that the hydrodynamic forces act to establish righting moments in the semisubmerged condition proportional to the volumetric displacement of the submerged portions of the stabilizing columns about the roll and pitch axes to locate and maintain the metacenter above the center of gravity of the vessel for all floating semisubmerged positions of the vessel. It may be noted at this point that the width of the twin hulled semisubmersible vessel imposes a restriction on the moment of inertia developed about the roll axis as the transverse distance of stabilizing columns 24 along each hull from the centerline of the vessel is limited to one-half the width of the vessel. The stabilizing columns 24 are therefore provided with water plane areas sufficiently large to compensate for the smaller moment arm in the transverse direction, and a preferred form of the vessel has the stabilizing columns located as close to the outboard sides of the hulls as possible, and in the illustrated embodiment portions of the columns are outboard of the hulls to further increase this righting arm.

While the preferred form of the vessel

described herein provides three or an odd number of pairs of columns, an even number of pairs of columns can be provided, four pairs 24 thereof being illustrated in the embodiments of the present vessel shown in Figures 10A—10B. It is seen, in this embodiment, that a like number of pairs of columns 24 are disposed on opposite sides of the transverse pitch axis PA and in a generally symmetrical relation thereabout, the middle pairs of columns thereof being spaced on opposite sides of the pitch axis PA.

The effective height of the stabilizing columns from the upper surfaces of the twin hulls to the under surface of the platform may be equal to and preferably slightly greater than the height of the maximum anticipated wave such that, in the floating semisubmerged condition, the hulls remain underwater and the platform above water for all waves. The stabilizing columns 24 also have a shape providing a constant cross sectional area throughout their effective height, thus presenting constant water plane areas to the water surface. Thus, submergence and emergence of stabilizing columns 24 due to wave action act to stabilize the vessel at a gentle stabilizing rate. If the cross sectional area of the upper half of stabilizing columns 24 were progressively increased in the upward direction, a shortened and undesirable roll and pitch period could occur with adverse effect on the drilling operation; and a progressive decrease in the cross sectional area of the upper half of the stabilizing columns 24 would result in large undesirable roll and pitch angles.

The magnitude of the cross sectional areas and hence the water plane areas and displacement of the present stabilizing columns is determined in part by the magnitude of the displacement of the hulls and satisfaction of other countervailing criteria. A sufficiently large column or bottle displacement is provided to afford adequate buoyancy to support the vessel in the semisubmerged condition with the hulls ballasted and providing a small proportion of total displacement. Sufficient water plane areas are provided for the columns or bottles to insure an adequate righting moment about roll and pitch axes with the roll and pitch angles not exceeding optimum limits. The column or bottle displacement, however, is sufficiently small so that large vessel displacements in heave are avoided. Additionally, the water plane areas are small enough to provide a longer period of roll which provides safe and comfortable operating conditions. The reduced water plane area also generally minimizes the wave action against the vessel.

A crane 84 is located adjacent one side of the raised platform to service the self-contained drilling rig. A second crane 88 is preferably also provided on the opposite side of the vessel for like purpose.

The twin hull stability of the present semisubmersible vessel is great enough to enable the vessel to carry heavy deck loads and to be employed as both a drilling and tender barge. In a drilling and tender barge, one of the small cranes 84 or 86 will be eliminated and a heavy duty crane (e.g., 150 ton lift capacity) would be substituted; this crane would preferably be mounted on one of the central columns 24 to utilize the column for structural support. In this usage, not only does ballasting the hulls submerge the vessel to provide a stable platform for drilling operations, but also the hull compartments 96 can be selectively ballasted to correct the vessel in heel and trim, respectively, to offset the weight of, and variations in, loads applied to the vessel via the crane. Further, the ballast correction can be applied to the vessel in both the floating and semisubmerged conditions.

It will be appreciated that the foregoing described vessel may be employed in other types of marine operations and fitted out with suitable structure consonant with such employment. For example, instead of mounting a drilling rig on platform 38, the semisubmersible column stabilized vessel of this invention may be adapted by mounting a heavy duty crane thereon along the centreline of the vessel, with other portions of the vessel being constructed similarly to corresponding portions of the vessel herein described and illustrated, with appropriate modification as to size. That vessel modification may be used entirely as a heavy duty derrick barge.

It is therefore seen that the objects of the present invention are fully accomplished in that the present vessel provides a deep water drilling unit having rapid mobility in transit between drilling sites as well as an exceedingly stable structure when semisubmerged to drilling depth over a drill site. Moreover, the vessel provides for a self-contained drilling operation or as a tender servicing other drilling structures.

WHAT WE CLAIM IS:—

1. A semisubmersible vessel including; a pair of elongated hulls disposed in spaced side-by-side substantially parallel relation one to the other; a working platform and means connected to said hulls and said platform to support said platform in spaced relation above said hulls; said connecting means including a plurality of upstanding stabilizing columns located on said hulls on opposite sides of the pitch and roll axes of the vessel, respectively, said stabilizing columns extending above the hulls a predetermined effective height at least equal to the maximum anticipated wave height; said hulls having a com-

bined displacement sufficient to float the vessel with the hulls having freeboard, and means for ballasting and deballasting the vessel to respectively submerge the hulls and a portion of said connecting means below the waterline and refloat the vessel with the hulls having freeboard, the displacement of the submerged hulls and the portions of said connecting means being sufficient to maintain the vessel buoyant in semisubmerged condition with the mean waterline located a distance above the hulls of substantially one-half the effective height of said stabilizing columns; said connecting means being spaced one from the other to provide an open frame area between the components thereof and between said hulls and said platform; said stabilizing columns being located to provide moment arms about said roll and pitch axes such that the buoyancy forces serve to establish righting moments proportional to the volumetric displacement of said submerged column portions; said stabilizing columns serving to provide motion minimizing characteristics in roll, pitch and heave when the vessel is in the semisubmerged condition.

2. A vessel as claimed in claim 1 wherein said stabilizing columns are substantially vertical with a substantially uniform cross-sectional area throughout their effective height.

3. A vessel as claimed in claim 1 or 2 which has a stabilizing column on each hull adjacent opposite ends thereof, and a stabilizing column on each hull located adjacent the transverse axis through the center of flotation.

4. A vessel as claimed in any of claims 1 to 3 wherein said connecting means includes a plurality of support members forming trusses extending between said hulls and said platform at spaced longitudinal positions along the vessel.

5. A vessel as claimed in claim 4 wherein said trusses include transversely extending members connecting one hull to the other, said members lying above the uppermost portions of said hulls.

6. A vessel as claimed in any of the preceding claims wherein said stabilizing columns have a substantially oval cross section and extend longitudinally parallel to said hulls a distance greater than their width.

7. A vessel as claimed in any of the preceding claims wherein said stabilizing columns are connected to said hulls on outboard sides thereof, the moment arm extending from the pitch axis to the center of the stabilizing columns on opposite sides of the pitch axis being longer than the moment arm extending transversely from the roll axis to the center of the stabilizing columns on opposite sides of the roll axis.

8. A vessel as claimed in claim 7 wherein said stabilizing columns have outboard portions thereof which extend transversely beyond the outboard sides of the respective hulls thereby providing increased moment arms for stabilizing action about the roll axis.

9. A vessel as claimed in claim 4 or 5, wherein said truss formations extend vertically between said hulls and said platform, the truss formation next adjacent one end of the vessel being displaced inwardly from the ends of said hulls at said one end of the vessel a sufficient distance to provide an open area between said hulls unobstructed by between-hull framing adjacent said one end of the vessel and a drilling rig mounted on said platform above said recess.

10. A vessel as claimed in any of the preceding claims wherein said hulls have separate compartments spaced longitudinally therealong, said ballasting and deballasting means being operable to selectively ballast and deballast each of said compartments to stabilize the vessel about pitch and roll axes.

11. A vessel as claimed in any of the preceding claims including at least six stabilizing columns with first and second pairs thereof located on said hulls adjacent opposite ends thereof on opposite sides of the vessel pitch axis, at least three of said stabilizing columns being located on said hulls on each side of the vessel roll axis, the cross sectional area of said columns being substantially constant throughout the effective height thereof.

12. A vessel as claimed in claim 11 wherein said vessel has six stabilizing columns with a column disposed on each hull located adjacent the pitch axis of the vessel and with the three columns on each hull being located in substantial longitudinal alignment.

13. A vessel as claimed in any of the preceding claims including at least three pairs of stabilizing columns, with at least three of said columns upstanding from each of said hulls on opposite sides of the roll axis of the vessel; said columns being located so that when the vessel has a total odd number of pairs of said columns, the middle pair of columns is adjacent the transverse pitch axis through the centre of flotation with the remaining pairs of said columns being disposed in equal numbers on opposite sides of the pitch axis and in generally symmetrical relation thereto, and so that when the vessel has a total even number of pairs of said columns, the middle two pairs of columns are on opposite sides of the transverse pitch axis with the remaining pairs of said columns generally symmetrically disposed thereabout.

14. A vessel according to claim 13 having an odd number of pairs of columns.

15. A vessel according to claim 13 having an even number of pairs of columns.

16. A vessel according to claim 14 wherein said transverse pitch axis intersects said middle pair of columns.

17. A vessel as claimed in any of the preceding claims including a drilling rig mounted on said platform over the space between said hulls.

18. A vessel as claimed in any of the preceding claims including a crane mounted on said platform.

19. A vessel as claimed in any of the preceding claims including means for anchoring the vessel in the semi-submerged position, said means including mooring winches located adjacent opposite ends of each of said hulls.

20. A vessel substantially as described with reference to figures 1—9 of the accompanying drawings.

21. A vessel substantially as described with reference to figures 10A and 10B of the accompanying drawings.

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FIG' I

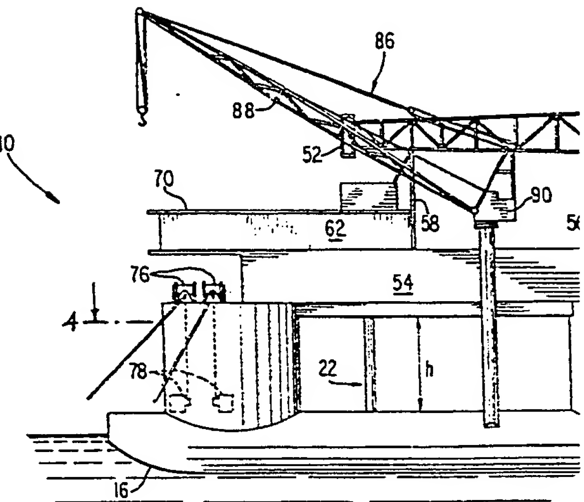
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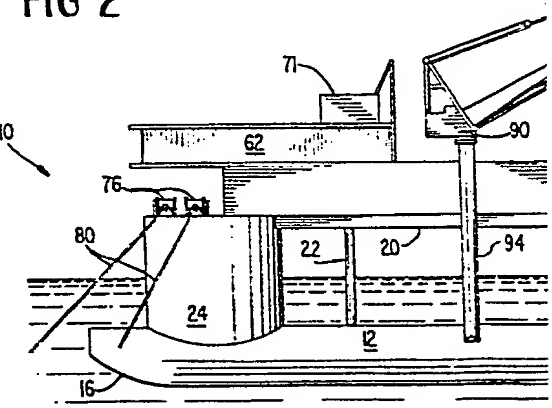
FIG 2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1212901 COMPLETE SPECIFICATION

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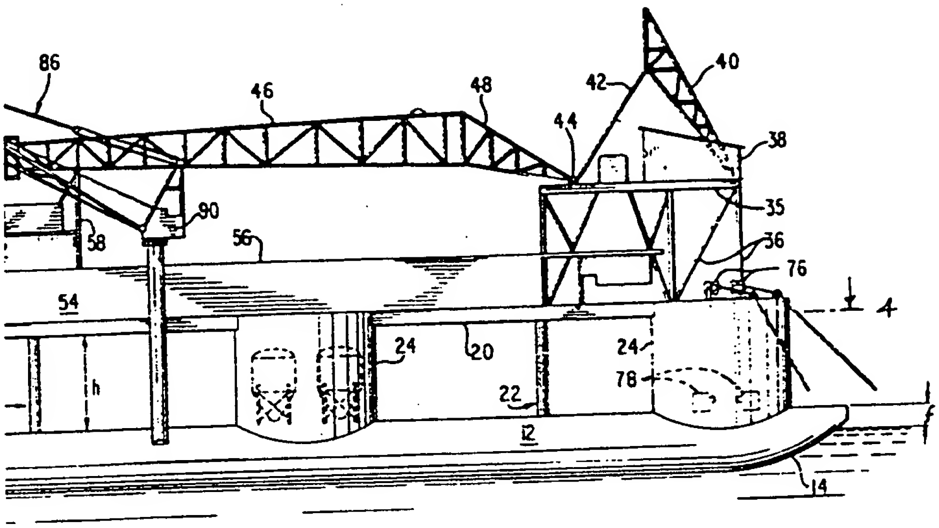

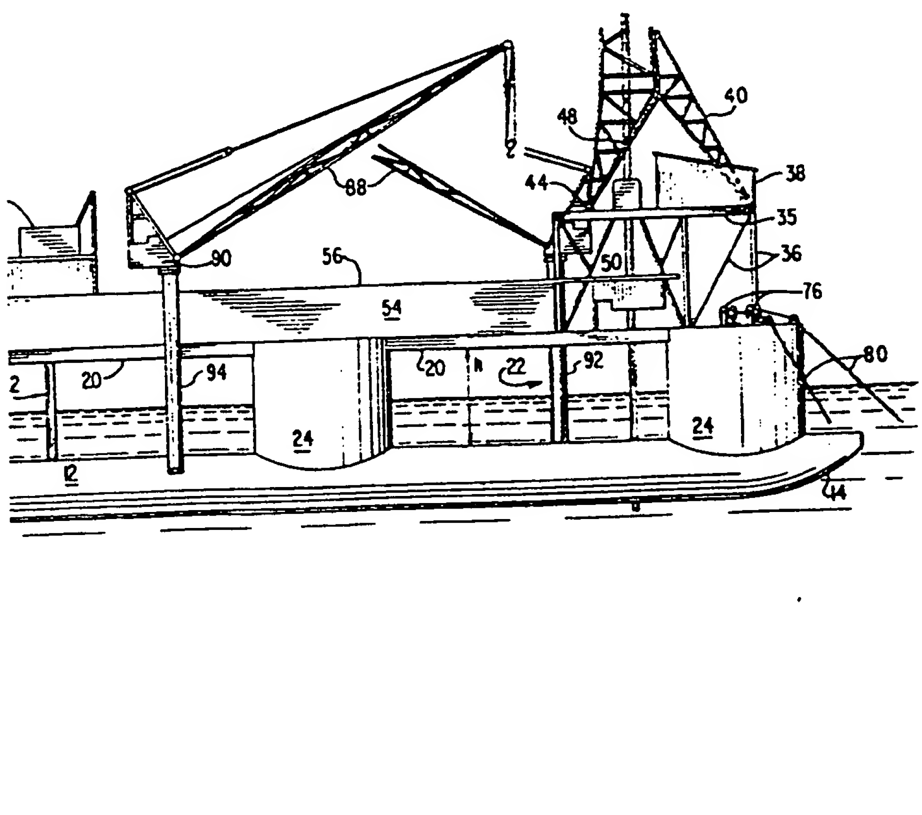

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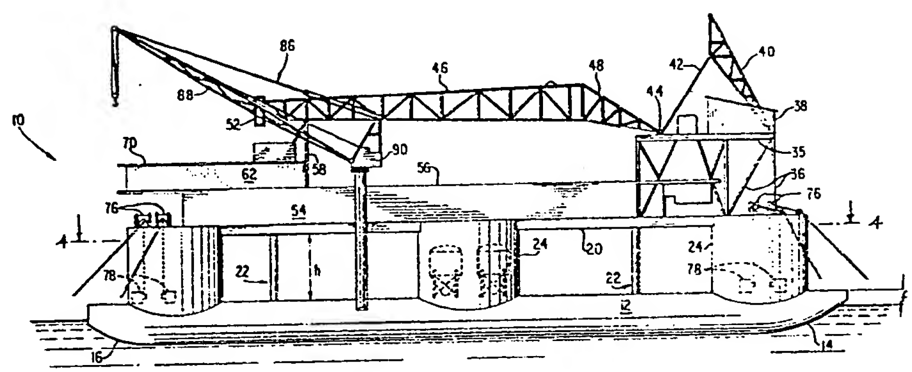
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FIG 2

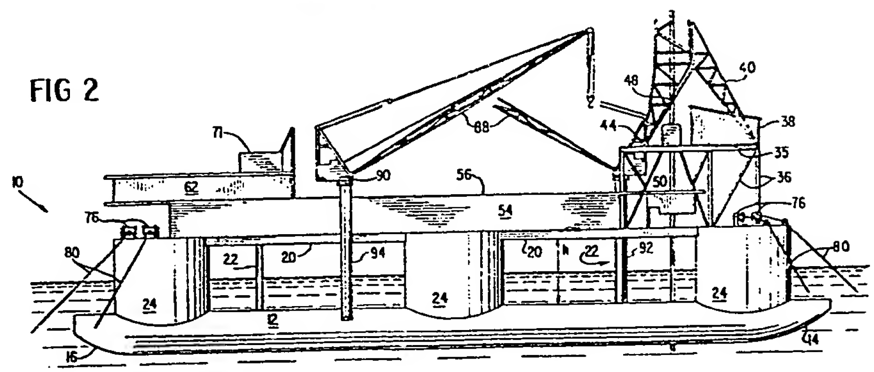
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FIG 3

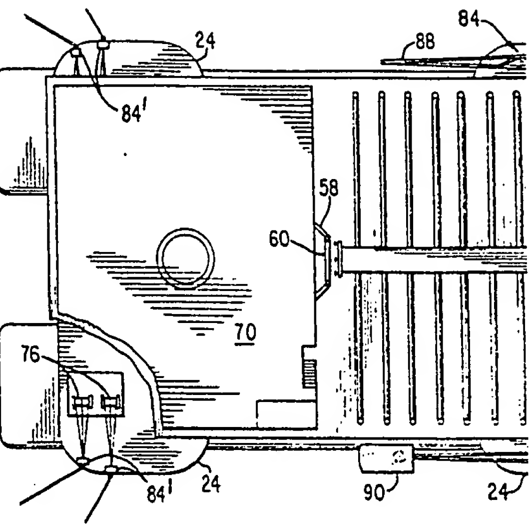
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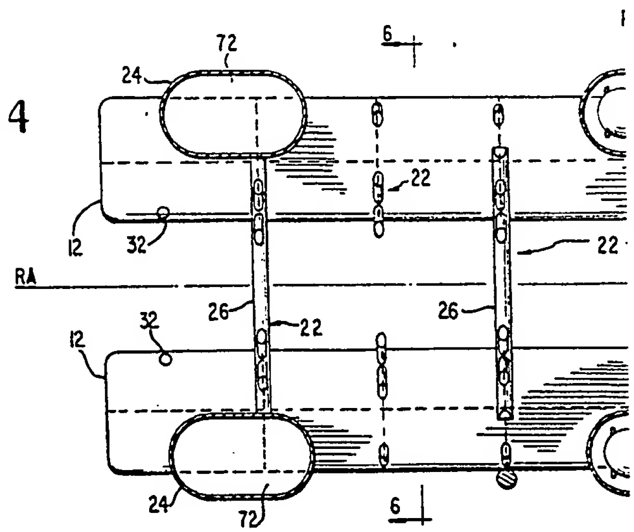
FIG 4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1212901 COMPLETE SPECIFICATION

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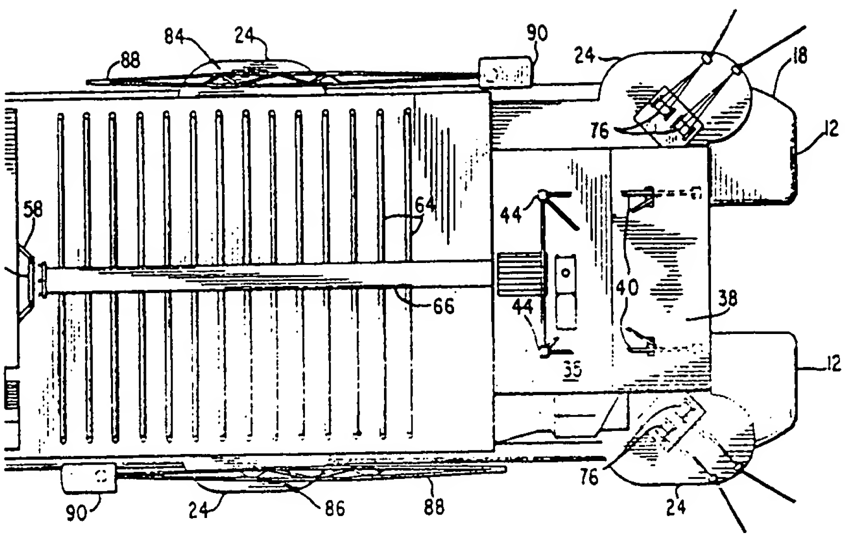

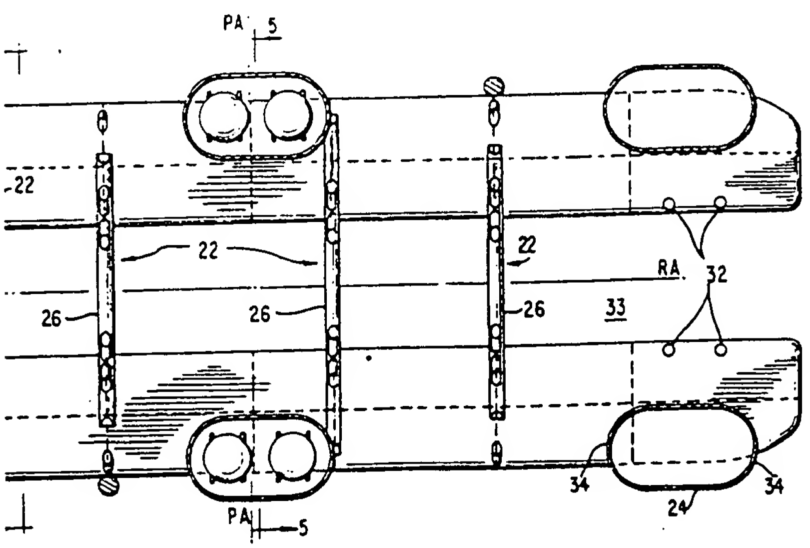

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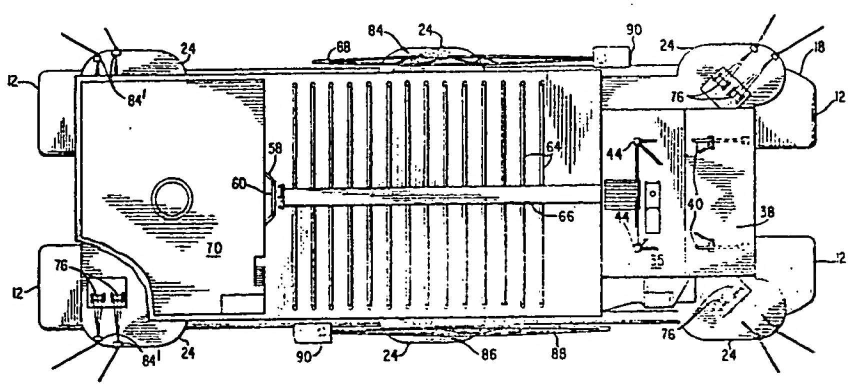
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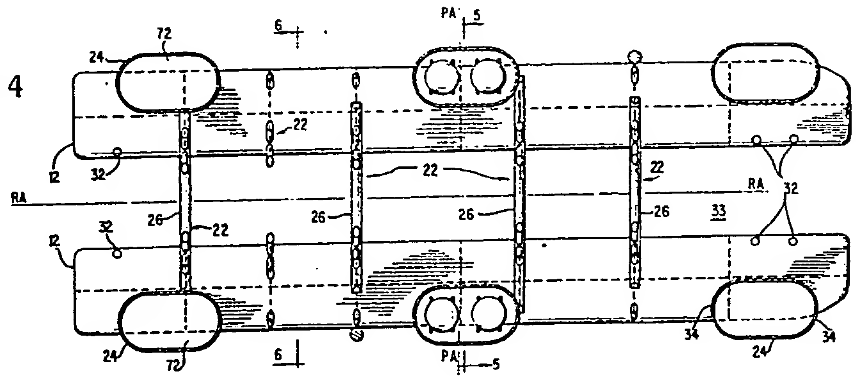
FIG 4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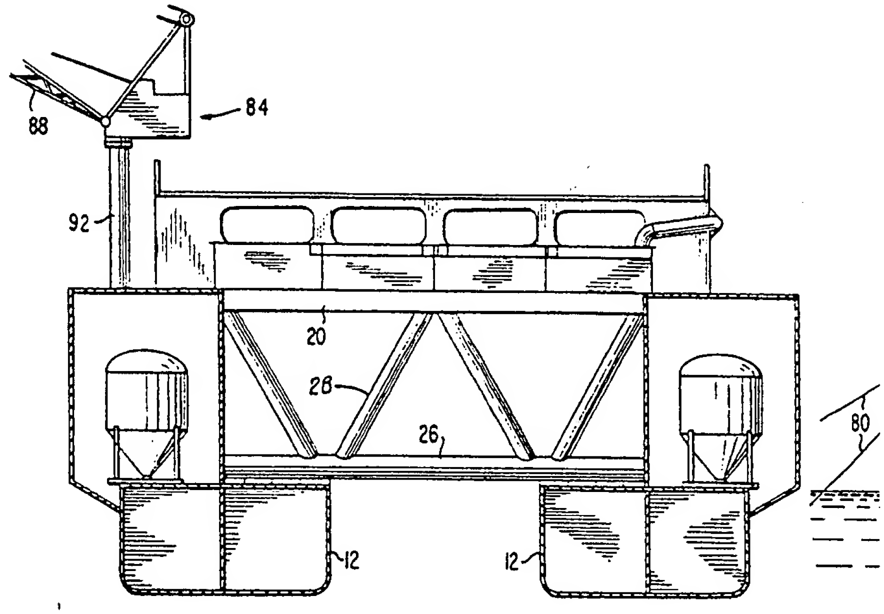

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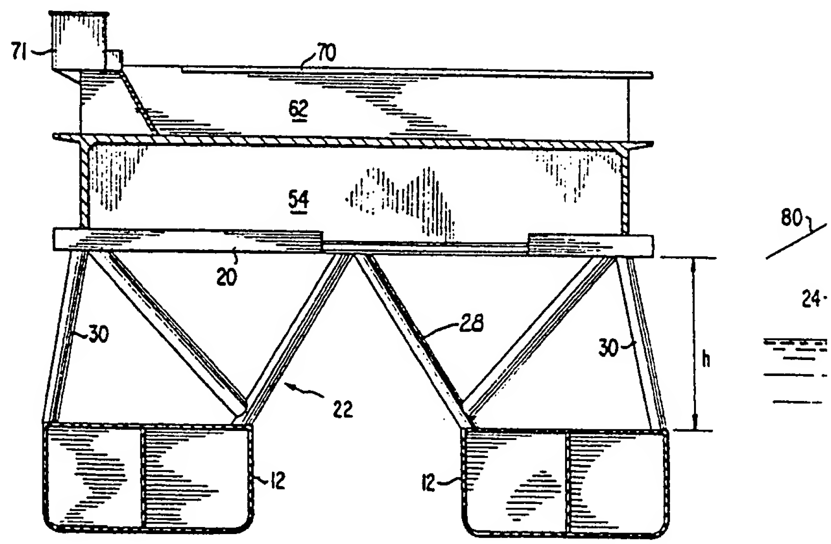

FIG. 6

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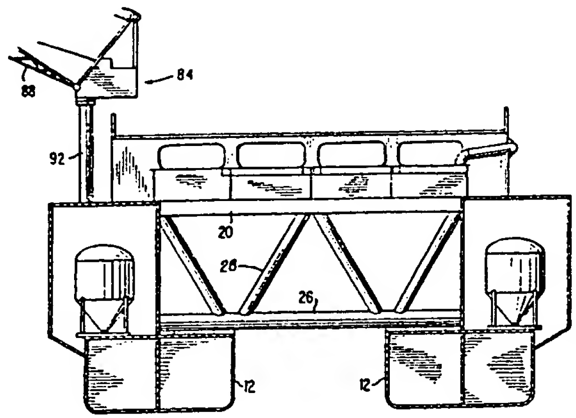

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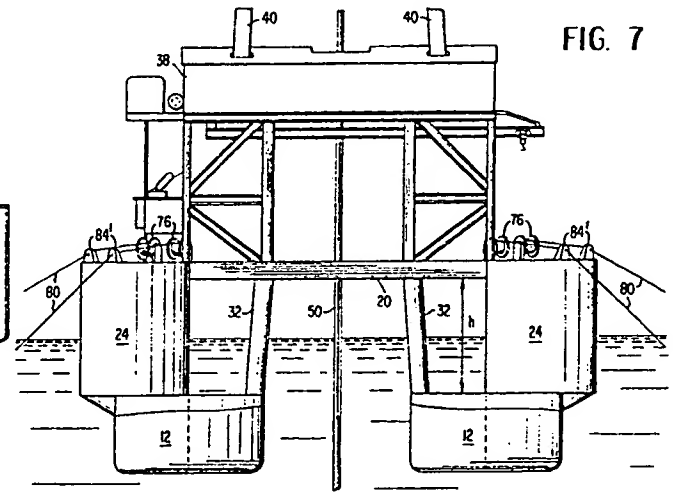

FIG. 7

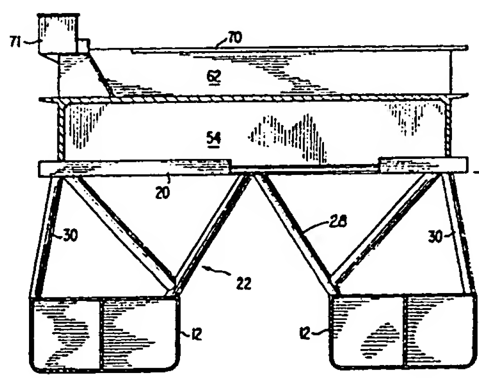

FIG. 6

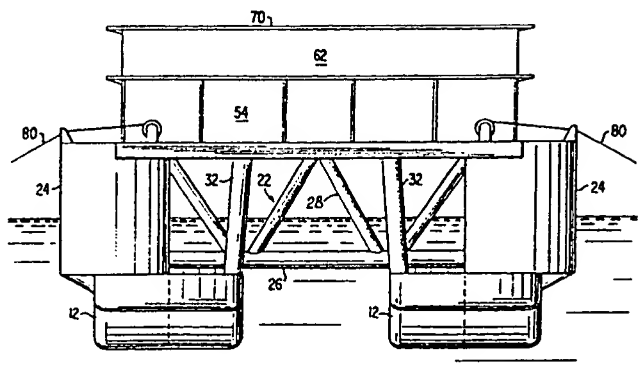

FIG. 8

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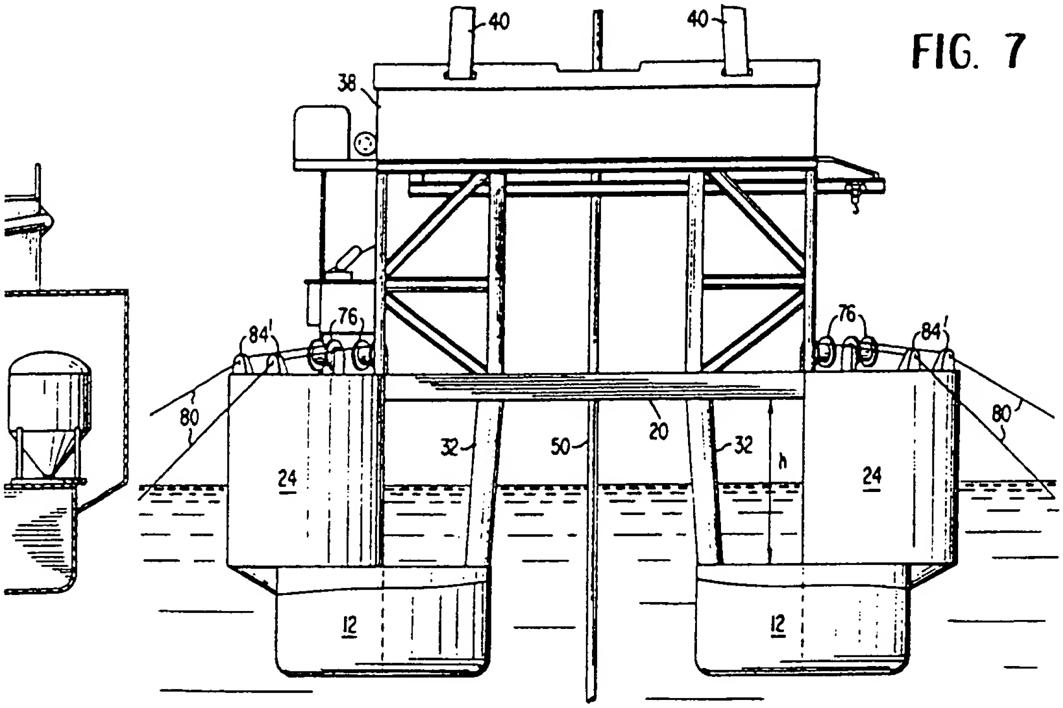

FIG. 7

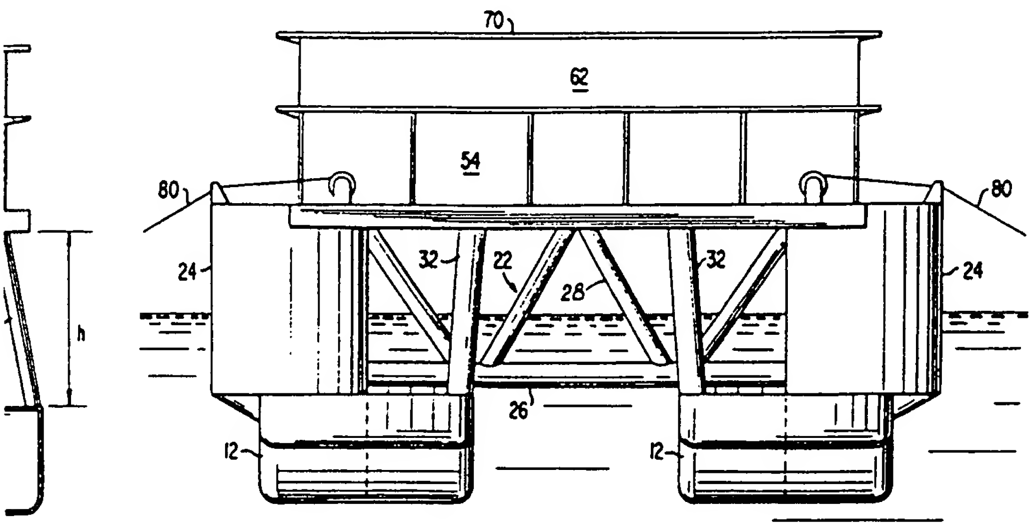

FIG. 8

1212901 COMPLETE SPECIFICATION

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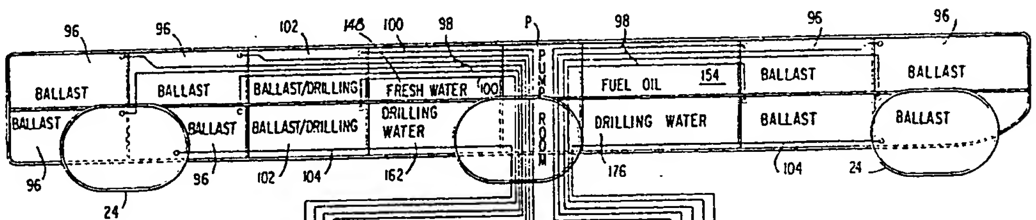

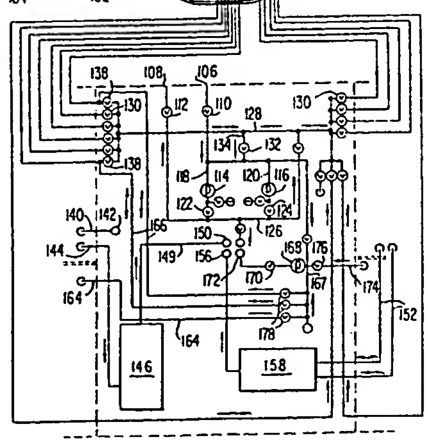

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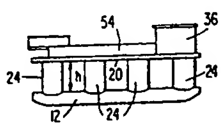


FIG.10A

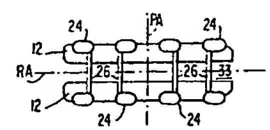
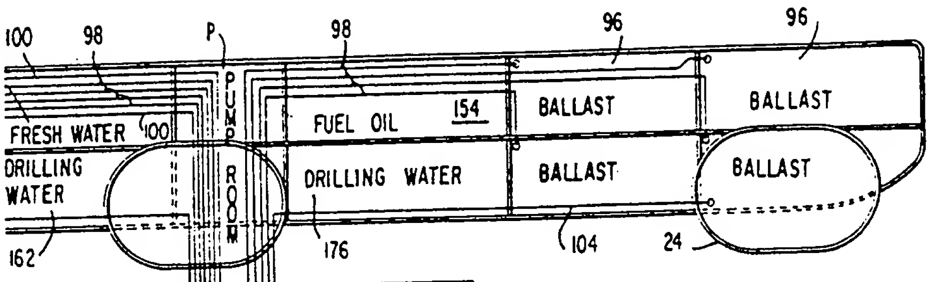


FIG.10B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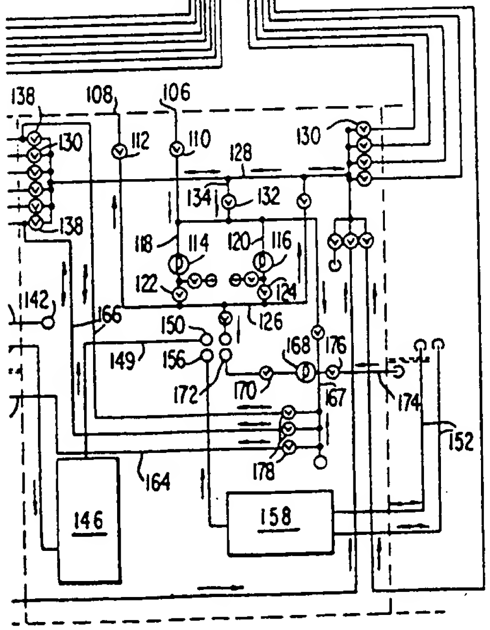
BALLAST
BALLAST
BALLAST
BALLAST



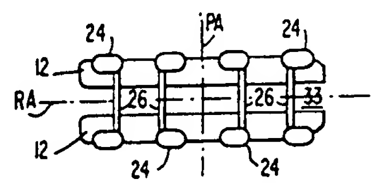
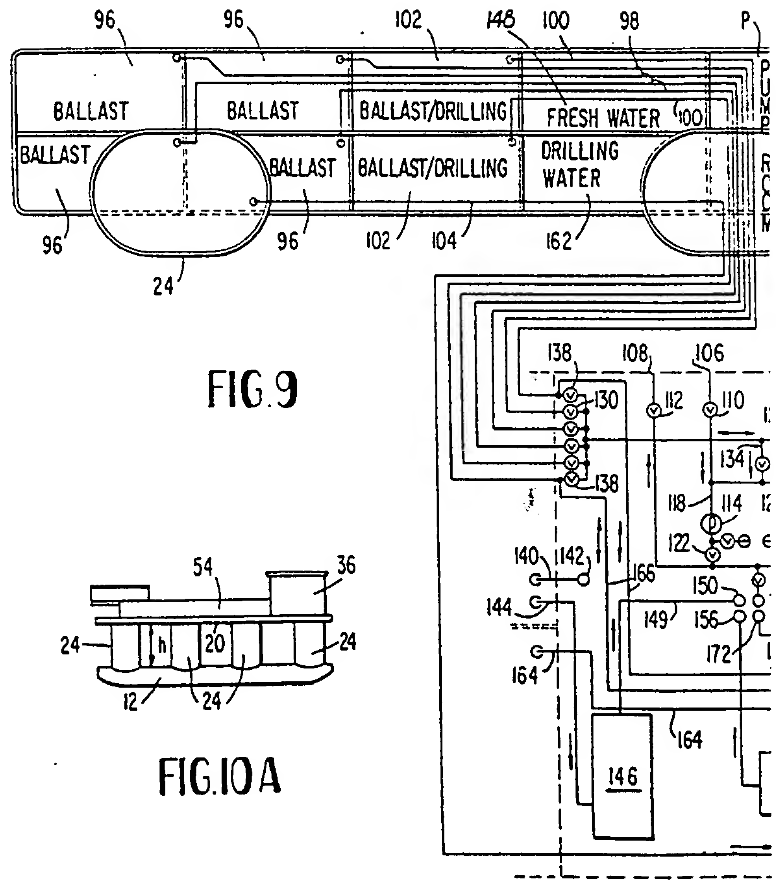


FIG.10B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172
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36
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h
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12
24

FIG.9

FIG.10A